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No. X.

Some Observations on the Anatomy and Physiology of the Alligator of North America. Lacerta Alligator, Gmel. Crocodilus Lucius, Cuvier. Communicated to the American Philosophical Society by N. M. Hentz, Member of the Academy of Natural Sciences of Philadelphia.—Read 21st July, 1820.

I WAS first induced to write the remarks which I have made on the anatomy of this animal, from observing the *singular structure of the organs of circulation*, presented on dissection ; which I believe have hitherto been inaccurately described. I frequently repeated my dissections, and always found the same organisation of those parts, and have concluded to lay my observations before the Society.

It is not my intention to give the whole anatomy of the animal ; such an attempt would be not only useless but altogether out of my power, under present circumstances ; and its osteology has already been ably described by M. Cuvier in the *Annales du Museum*. It is highly probable, however, that in Europe the examination of the viscera has been confined to very young subjects.

M. Correa de Serra had the goodness to inform me that a traveller in the West Indies, Descourtils, had written a dissertation upon the anatomy of this animal. M. Cu-

vier, in the tenth volume of the *Annales du Museum* mentions his name, and says that he had dissected thirty or forty alligators. The work of this author I have not been able to procure ; and I think it is not to be obtained in this country. Strongly impressed with the remarks of M. Correa de Serra, I had relinquished the idea of giving publicity to my remarks, believing that the subject had been treated accurately by able anatomists ; but reflecting that this traveller wrote in 1806 or 1807,—that in the *Règne Animal*, published in 1817, at least ten years after, M. Cuvier describes the circulation in the crocodiles, as similar to that in the *chelonians* or turtles,—and that the result of my dissections is far from coinciding with that description, I concluded that an error must still exist in regard to that important point of anatomy and physiology.

I now therefore lay before the American Philosophical Society my notes, illustrated by several drawings of the heart, and leave them to judge of the correctness of my observations.

I thought proper to add the drawing of the alligator, which I have taken from the recent subject, because in the new *Dictionnaire d'Histoire Naturelle* I find that no correct representation of this animal has yet been made.

The circulation being the most important point, I shall begin with the description of the heart, and shall first give the descriptions and opinions of M. Cuvier.

In the *chelonians* or turtles, it appears that the heart is composed of two auricles and one ventricle, sometimes partly divided into two cells, which always communicate. It results from this organisation, that the blood returning from the different parts of the body, is partly propelled through the aorta ; and that a portion of the blood brought to the heart by the pulmonary veins, flows again by the pulmonary artery into the lungs. M. Cuvier thinks that the circulation is the same in the *Saurians*, which order includes the genus *Lacerta* of Linnæus, to which the alligator belongs. In his *Règne Animal*, M. Cuvier merely expresses

this opinion, but gives no particular description : in his *Comparative Anatomy*, however, he describes the structure of the heart in the crocodile. I shall here subjoin a literal translation of this passage, which must be compared with my observations: —

“ Heart of Reptiles.

“ We shall first describe the heart of crocodiles, because it furnishes us with an example of the most complicated structure that we have observed in animals of this order, or indeed in the whole class of reptiles.

“ The pericardium adheres, as in the *chelonians*, to the peritonæum, which covers the convex surface of the liver, and its point is retained by a very strong tendinous chord to the free portion of the sack, which is extremely thick, and exteriorly of a fibrous structure. It is fixed on one direction between the two lobes of this viscus ; on the other, between the two lungs. The auricles, a little smaller than those of the *chelonians*, have however the same relations, thick parietes, closed by strong fleshy columns, crossing in different directions. The ventricle, properly so called, presents an oval form, and very thick parietes ; its cavity is *divided into three cells, communicating with each other by many orifices*, but giving, nevertheless, to the blood which they receive a sufficiently determinate course. One of these cells is inferior, and on the right : the auricle of the same side pours out the blood which it receives from the veins of the body by a large opening, bordered with two valves and placed at the most advanced part of this cell : upon the left side of this same cell, but still before, we find the opening of the left descending aorta ; and behind this opening, an orifice which leads to the smallest of the three cells, placed at the middle part of the base of the heart, and into which opens the common trunk of the pulmonary artery.

“ Consequently, the blood which arrives from the right

auricle into the cell of the same side, has two courses to take :—1. That of the left descending aorta ; and 2. That of the pulmonary cell which forces it into the artery of the same name ; it may even take a *third* route, in filtrating through *numerous canals* that traverse the partitions which separate the two preceding,—the left and superior cell. The left auricle propels into this the blood which it has received from the pulmonary vessels. Its opening is bordered on the right side with a membranous valve, to the right of which opens the common trunk of the right descending aorta, the carotids, and the axillaries ; which blood, passing into this trunk, is distributed particularly to the head and to the extremities ; or it filtrates through the intervals of the fleshy columns of this cell, and penetrates into the two others. It results from this, that the carotids and the axillaries carry to the anterior portion of the body, the iliacs to the posterior portions, and the median sacral to the tail, the blood which comes almost entirely immediately from the lungs ; whilst a portion of that which takes its course for the viscera (by the left aorta) comes from the right cell, and from the auricle of the same side ; and consequently has not traversed the lungs in order to be modified by the surrounding element. The pulmonary blood does not mix then so well with that of the body, as in the chelonians. Such is the structure of the heart in the crocodile of the Nile and the Caïman.” *Cuv. Anat. Comp. Vol. IV., p. 221.*

I shall now give the result of my dissection, which differs very much from the preceding description :—

The heart, in the alligator, is placed in the centre of the thorax, exactly under the middle of the sternum ; it occupies a large space between the two lobes of the liver and the lungs. The heart itself however is not as large as might be expected from the mere inspection of it, when contained in the pericardium: the arterial tubes, nearly as bulky as the auricles and ventricles together, fill a great space in the pericardium, which contains besides a large quantity of lubrica-

ting fluid. The parts composing this organ are two auricles, two very distinct ventricles, a set of veins from the body, the pulmonary artery, two veins of the same name, a branch for the aorta on the left, another for the right side, the right subclavian, and the carotid artery. I shall now describe these parts, beginning with the veins returning from the body :

The vena cava descendens follows for a time the right subclavian artery ; it enters the upper part of the pericardium, and is attached to the inner coat of this membrane until it joins the vena cava ascendens, opposite to the right auricle, where they unite. This vein runs along the right side of the vertebræ, until it reaches the inner and lower part of the large lobe of the liver ; there it enters this organ, running in a perfectly straight channel, formed near the edge of this viscus, receiving from it a great number of veins, and comes out a little above the gall-bladder, where, along with four or five *venæ hepaticæ*, it enters directly the pericardium. This is closely attached to the liver, as M. Cuvier observes, but more so in that part than any other. There is another vein bringing the blood from the left axilla, which pierces the pericardium near and above the left pulmonary vein, and enters the *sinus venosus*. This vein is analogous to the left subclavian (of the human subject,) differing only from this, in its entering the right auricle *separately*: this, and several important observations, I owe to Dr. Harlan, who has examined the heart with me. These three veins empty themselves into the right auricle, which, rather larger than the left, is situated above and on the right side of the heart. The right ventricle, very muscular, has, like the left, thick parietes ; it extends a little lower than the other, and is rather more spacious ; it is furnished with two large valves situated near the orifice of the auricle to prevent the return of the blood. This ventricle has an opening into two arterial tubes ; one on the left and superior part is furnished with two semilunar valves opposed to each other, and opens into the splanch-

nic or left aorta. At this place, the partition between the two ventricles is not as thick as below, but there is a cartilaginous septum, which is so placed as to divide and give elasticity to the orifice of the pulmonary artery, and the splanchnic or left aorta. I have endeavoured in vain to find here a direct communication with the left ventricle. The pulmonary veins pass under the *bronchia*, and pierce the pericardium behind; they then unite, and enter the left auricle, which is placed on the upper and posterior part of the base of the heart. The left ventricle is situated partly behind the other; it extends a little higher, and seems to be rather smaller; it is furnished, like the other, with two valves, placed before the orifice of the auricle; it has also an opening into two arterial tubes; the first leads into the left or splanchnic aorta, and is only separated from the orifice of the right ventricle into the same artery by the cartilaginous partition: it is bordered by a valve, which nearly closes it, so that a very small quantity of blood only is allowed to pass from this ventricle through the opening. The other passage for the blood is placed above; this arterial tube divides into *three* branches—one which forms the right or systemic aorta, another forming the right subclavian, and a third the carotid artery, which at first inclines on the left side, sends a branch which is the left subclavian, and previous to its entering the cranium, divides into two branches. This common tube, together with the left aorta, and the canal for the pulmonary arteries, is united, and forms a large arterial sack, situated above the heart, which is inclosed within the pericardium: the arteries divide into branches as they pierce through this sack. These three canals, above the ventricles, and before leaving the pericardium, are extremely enlarged, and form wide bags, capable of containing more blood than all the cavities of the heart together. Such I always found the structure of the heart in the alligator.

Thus the blood coming from the body is introduced into the right auricle; from this cell it flows into the right ventricle, which propels it into the pulmonary artery, and partly

into the left aorta. On the other side, the pulmonary veins bring the blood from the lungs into the left auricle, which discharges it into the ventricle of the same side ; from thence it is propelled into the right aorta, the right subclavian, and the carotid artery. It appears, that the circulation goes on in this manner whilst the animal is allowed to breathe ; but when it is confined under water, when the lungs have ceased in part to perform their office, the right ventricle must send a greater quantity of blood into the left aorta, which becomes filled with an increase of the fluid ; the weight and pressure must act on the valve, which, as I have already observed, allows but a very small quantity (if any) of the blood coming from the left ventricle to penetrate into the left aorta.

M. Cuvier describes the ventricle as being *divided into three cells, communicating with each other by many orifices*. I have proved, if my observations are correct, that there are two ventricles, very distinct, and having no manner of communication from one to the other through their partition ; only nature has placed a large arterial tube (the left or splanchnic aorta,) which has a communication with the right or systemic aorta, and which being capable of great distention, when filled with the fluid, empties part of its contents into the right aorta.

This structure which M. Cuvier thinks analogous to that in the cheloniens, differs essentially from it. In turtles, a mixture of arterial and venous blood takes place in the ventricle : whilst in the alligator, when the left aorta becomes much distended with blood, which must be the case when the animal is under water, this artery may supply the left ventricle with part of its contents, but the two semilunar valves placed at the orifice of the right ventricle into this tube prevent the introduction of any part of the fluid into it from the arterial canal, so that the lungs never receive blood which has not passed through the system. Moreover, when the animal is exposed to the atmosphere, when the lungs receiving the regenerating element, allow the venous blood to flow towards these organs, both ventricles must re-

ceive an equal proportion of the fluid; the right aorta receives a greater quantity, and the left aorta must cease to be distended with a surplus of blood, whilst that part of it contained in the left ventricle must act upon the valve placed before the orifice leading to this same left aorta, and thus prevent the flowing of the blood from that artery. In this state, the other arteries are supplied with nearly pure blood. Such is the result of my observations. It appears that M. Cuvier, whose anatomical knowledge is well known, has dissected only a small alligator which was sent alive from the West Indies, which, though it died on the passage, arrived in time to be examined. Youth, disease, and several other causes, may have rendered this body an unfit subject to examine with certainty those organs; which I have dissected several times in large animals, soon after their being deprived of life.

In the alligator, the muscles are not very numerous, but extremely large in general, and strong; those of an animal killed as it has just left its winter retreat, are white and flaccid; they stand several days in the open air without any alteration, whilst the muscles of one killed in the summer are red, more firm, and resemble those of any animal with double circulation, except in their great contractile power after apparent death. I shall enumerate those muscles which are most conspicuous. On the thorax, there is an extensive pectoral muscle, covering nearly all the ribs, and inserted on the humerus; there is above, a flat and long muscle extending from the sternum to the lower jaw by one fasciculus, and to the larynx by another; one extending from the clavicle to the larynx; another arising from the *os hyoides*, covering the larynx, and ending at the point of the tongue; and a last smaller muscle, arising from the *os hyoides*, and attached to the lower jaw. These muscles having connections with the throat, bring down the larynx and the tongue, and probably assist deglutition. The most important muscle of the abdomen is one that arises from the *os pubis*; it passes under the abdominal ribs which have been described by M.

Cuvier, and is attached very closely on the anterior surface of the two lobes of the liver ; a thin aponeurosis extends farther and nearly surrounds this organ ; the contraction of this muscle must move down the liver, the heart itself, and indeed most of the viscera contained in the abdomen. Fibres from the above mentioned aponeurosis are attached behind the liver to the ribs, forming a sort of diaphragm, or a partition which divides the thoracic from the abdominal viscera. The last which I shall mention, remarkable for its size, arises from the first inferior process of the vertebra over the lungs ; as it comes out of the thorax, it all at once grows very thick, and sends on each side a tendon which is attached to the first rib ; it tapers gradually above, and is inserted into the sphenoid bone ; it appears to me to be an antagonist to the muscles of the neck. The lower muscle of the tail is inserted on the pelvis, and to the femur by a tendon on each side. The *intestinal canal* is not very large ; the œsophagus is extremely thick, and capable of great distention ; the stomach has a rounded oblong form ; on the right side, close by the orifice of the œsophagus, is that of the duodenum. This intestine, near the end of its second turn, receives the duct of the gall bladder. Near the end of the rectum, on each side, are two *intestina cæca* ; they at first take a direct course upwards ; above they lie in a vermiform position, fixed by a folding of the mesentery.

I always found the stomach empty, with the exception of some gravel and a few small pieces of wood. It is generally believed in Carolina, that the alligators swallow a piece of the resinous knot of the pine tree, before they retire to their winter retreat. A glass stopper has been found in the stomach of one, which had assumed a round form.

On each side of the anus there is a gland, which contains a thick yellow fluid having a strong smell of musk ; but this smell is perceptible in every part of the body in old animals. M. Cuvier (*Règne Animal*) states, that on each side of the throat there is the orifice of such a gland : on dissecting this part, I found a small bag having an opening near the lower jaw ; it contained some particles of sand ; towards the bot-

tom of this bag there is a white glandular substance, which, when opened, presents no cavity discernible by the naked eye, and is destitute of smell; the fore extremity of this is terminated by a similar substance, in the form of a cord, which is attached to the extremity of the cornu of the *os hyoides*. Several gentlemen informed me that when the animal is wounded or angry, he contracts the lower muscles of his neck, and the two bags protrude. I have not been able to discover the use of these organs. It has been said, that in the alligators and turtles, the heart beats for a long period after being extracted from the body; for my part, although I dissected the animals immediately after they were killed, nay whilst their limbs still preserved a sort of involuntary motion, I always found that the heart had entirely ceased to contract.

I cannot close my remarks without mentioning a circumstance which I am unable to explain: Whilst dissecting these animals, I often found small bags, apparently formed by the cellular substance; they contained a black residuum, and some fine gravel: in one of them I discovered the elytrum of an insect of the genus *Dytiscus*, well preserved. There was no connection with the surrounding parts, and no cicatrix could be perceived in the skin near them. I even found one of these bags under the sternum. I leave it to future observation to explain how they are formed.

This is the amount of my observations on this singular animal during my residence in South Carolina. I regret that it is not more complete. I have endeavoured however to make known such facts only as appeared to me to be new, omitting those which are already known.

Since writing the above, I have had an opportunity, in conjunction with Dr. Harlan, of minutely dissecting a young alligator. The animal being injected, furnished clearer demonstrations of the correctness of my remarks.

The following is a brief exposition of the result. The mucous coat of the stomach is smooth, without rugæ. About one inch from the pylorus, there is a constriction of the duodenum, forming another pylorus; immediately beyond this, the duodenum forms a loop, in which is found the *pancreas*; through this gland passes the gall duct. There is not the least vestige of the *valvulæ conniventes* throughout the intestines; but in place of them are transverse constrictions forming the alimentary canal into numerous cells, which must necessarily impede the progress of the contents. There was no blind gut in this animal.

In this subject, which was three feet ten inches long, the intestines were five feet in length.

The spleen lies beneath the duodenum, above the vertebræ. The left aorta, in the abdominal cavity, previous to its visceral divisions, gives off a considerable branch, which communicates with the right descending aorta; the rest divides into several branches distributed to the abdominal viscera.

The bag under the throat, in this young animal, contains a musky substance.



Letter from Dr. Harlan to N. M. Hentz, Esq. containing some further Observations on the Physiology of the Alligator.

Philadelphia, 19th May, 1824.

DEAR SIR,

Since I had last the satisfaction of communicating with you, I have enjoyed another opportunity of dissecting an alligator, three feet in length, which had lived several months in the Philadelphia Museum. As the following facts tend to confirm the observations we made some time ago, on three individuals, I hasten to communicate them, in order to give

you an opportunity of adding them to your paper, which I understand will soon be published. This dissection was performed on the 6th of January, 1824.

1. I forced air into the vena cava ascendens, which injected the right auricle and ventricle, passed into the lungs through the pulmonary artery, and into the splanchnic aorta, also into the systemic aorta through the valvular opening at the base of the former.

2. I forced air into one of the pulmonary veins, which inflated the left auricle and ventricle, passed into the systemic aorta and the subclavian trunks which leave the supercordial sack.

The apex cordis was not attached to the pericardium, as is usually the case.

The circulation of these animals is briefly as follows :

The blood passes from the right auricle into the ventricle of the same side. From this cavity there are three openings:—1. One into the systemic aorta, by a valvular communication at its base, which allows the continuation of the circulation, when the progress of the blood through the lungs is impeded by expiration.—2. One into the pulmonary artery—3. And one into the splanchnic aorta, carrying black blood to the viscera. During expiration, there is still some pulmonic circulation ; a small quantity of blood passing from the lungs into the left auricle to the ventricle of the same side, from whence it has a direct passage into the systemic aorta. The valve at its base will not permit even wind to pass into the right side ; nor will the semilunar valves of the aorta permit regurgitation ; so that the only mixture of the black and red blood takes place in the systemic aorta, during expiration or collapse of the lungs.

With sentiments of respect,

I remain your friend, &c.

R. HARLAN.

N. M. Hentz, Esq.

EXPLANATION OF PLATE II.

*Figure 1.**

- a* The heart contained in the pericardium.
- b—b* The vena cava descendens.
- c—c* The pulmonary arteries.
- d—d* Left axillary vein, or subclavian.
- e—e* Pulmonary veins.
- f—f* Left or splanchnic aorta.
- g—g* Right or systemic aorta.
- h—h* Carotid artery.
- j—j* Right subclavian artery.
- i* Trachea.
- k* Bronchia.
- l* The lungs.
- m* The liver.
- n* Muscle covering the liver.
- o* Œsophagus.

Figure 2.

This figure represents the heart, the pericardium being opened ; and a section of the right ventricle and the left aorta.

- 1. Sinus venosus.
- 2. Right auricle.
- 3. Orifice of the right auricle into the ventricle of the same side with the valves.
- 4. The right ventricle cut open.
- 5. Orifice of the pulmonary artery.
- 6. Pulmonary artery, which being situated behind, is merely indicated.
- 7. Left aorta cut open.
- 8. Semilunar valves.
- 9. Cartilaginous septum.
- 10. The whole arterial trunk.
- 11. Part of the left auricle.
- 12. Attachment of the ventricles to the pericardium which is mentioned by M. Cuvier.

Figure 3.

This represents the heart viewed behind.

- 1. The left ventricle cut open.
- 2. The orifice of the left anricle, with the valves.
- 3. The opening into the left aorta nearly closed by the valve.
- 4. The common tube for the right aorta, partly cut open.

* The latter of the double letters in Figure 1, have reference to Figure 2, in the Plate